United Nations

ECE/TRANS/GRPE/2013/xx
GFV 29-02e

Economic and Social Council

Distr.: General
Date

Original: English

Economic Commission for Europe

Inland Transport Committee

World Forum for Harmonization of Vehicle Regulations

Working Party on Pollution and Energy

Draft new Regulation on uniform provisions concerning the approval of specific LPG (liquefied petroleum gases) or NG (compressed natural gas/bio-methane/liquefied natural gas) dual fuel retrofit systems and dual fuel retrofitted engines to be installed in heavy duty applications

Submitted by the experts from AEGPL

Draft rev.00 First issue.

Regulation No. xx

Draft new Regulation on uniform provisions concerning the approval of specific LPG (liquefied petroleum gases) or NG (compressed natural gas/bio-methane/liquefied natural gas) dual fuel retrofit systems and dual fuel retrofitted engines to be installed in heavy duty applications.

Contents

1. Purpose

This regulation provides a harmonized method for the classification, evaluation and approval of:

- dual fuel retrofit systems to be fitted in heavy duty road vehicles with compression ignition engines to permit to use of LPG or NG (compressed natural gas/bio-methane/liquefied natural gas) in dual-fuel mode;
- dual fuel retrofitted engines to be fitted in heavy duty road vehicles equipped with compression ignition engines
- retrofitted vehicle type with an approved dual fuel retrofitted engine;
- reserved[1]

2. Scope

2.1 This Regulation applies to dual fuel retrofit systems and dual fuel retrofitted engines intended to be fitted on vehicles of categories M and N[2], with the exception of:

(a) Vehicles type-approved pursuant to Regulation No. 83

(b) Vehicles with engines type-approved pursuant to Regulation No. 49, 00 or 01 or 02 series of amendments,

(c) Vehicles with engines type-approved pursuant to Regulation No. 49, 03 or 04 or 05 series of amendments, in accordance with row A of table 1 and 2 of par. 5.2.1. of the those regulation,

(d) Vehicles type-approved pursuant to EC Directive 70/220/EEC,

(e) Vehicles with engines type-approved pursuant to EC Directive 88/77/EEC up to and including the amending Directive 96/1/EC.

(f) Vehicles with engines type-approved pursuant to EC Directive 88/77/EEC including the amending Directive 2001/27/CE, in accordance with row A of table 1 and 2 of par. 6.2.1. of the same directive,

(g) Vehicles with engines type-approved pursuant to EC Directive 2005/55/EC in accordance with row A of table 1 and 2 of par. 6.2.1. of the same directive.

2.2. As regards to the installation of dual fuel retrofitted engine, this regulation applies to retrofitted vehicles of categories M and N with the exception of vehicles specified in par. 2.1 (a) to (g)

[1] This paragraph is reserved for future requirements for non-road mobile machinery, agricultural and forestry tractors engines, approved according regulation No. 96.

[2] As defined in Annex 7 to the Consolidated Resolution on the Construction of Vehicles (R.E.3), (document TRANS/WP.29/78/Rev.1/Amend.2, as last amended by Amend.4).

3. Definitions

For the purposes of this Regulation the definitions listed in par. 2 of annex 11 of regulation no. 49 05 series of amendment and par. 2 of annex 15 of regulation no. 49 06 series of amendment shall apply, unless otherwise stated in the following subparagraphs.

The following definitions also apply:

3.1. "*Heavy duty road vehicle*" means an heavy duty vehicle of categories M and N with the exceptions listed in (a) to (g) of par. 2.2, equipped with an heavy duty diesel engine for its operation.

3.2. "*Diesel mode*" means the operating mode of a dual-fuel engine during which the engine does not use any gaseous fuel for any engine operating condition.

3.3. "*Dual fuel mode*" means the operating mode of a dual-fuel engine during which the engine simultaneously uses diesel fuel and a gaseous fuel at some engine operating conditions.

3.4. "Approval of a *Heavy Duty Dual Fuel (HDDF) retrofit system"* means the approval of a retrofit system intended to be installed in heavy duty engine applications to permit operation in dual fuel mode.

~~3.5. "*Specific Heavy Duty Dual Fuel (HDDF) retrofit system"* means HDDF retrofit systems which do not differ in such respect as:~~

~~3.5.1. ystem manufacturer (responsible for retrofit approval application);~~

~~3.5.2. Dual fuel retrofit system type~~

~~3.5.3. Pressure regulator/vaporizer type by the same manufacturer;~~

~~3.5.4. Gas fuelling system type by the same manufacturer (i.e. induction mixer, injector device, vapour or liquid, single or multi-point injection system);~~

~~3.5.5. Sensors and actuators set types;~~

~~3.5.6. The fuel container type (i.e. LPG liquid take off / vapour pressure, LPG vapour take off, LPG liquid take off / pressurized by pump, pressurized CNG take off), the safety devices and fuel container accessories, as required by Regulation No. 67, 01 series of amendments, or Regulation No. 110, where applicable (i.e. relief valve);~~

~~3.5.7. Fuel container fitting devices;~~

~~3.5.8. ECU type by the same manufacturer;~~

~~3.5.9. Basic software principles and control strategy;~~

~~3.5.10. Installation manual;~~

~~3.5.11. End user manual.~~

3.5. *"Approval of a Heavy Duty Dual Fuel (HDDF) retrofitted engine"* means the approval of an engine, originally designed and approved to operate with diesel fuel only, as a separate technical unit, that in addition can simultaneously operate with diesel fuel and a gaseous fuel, both fuels being metered separately, where the consumed amount of one of the fuels relative to the other one may vary depending on the operation.

3.6. *"Approval of a Heavy Duty Dual Fuel (HDDF) retrofitted vehicle"* means the approval of a vehicle with regard to the installation of a retrofitted HDDF engine

~~3.7 *"Dual fuel engine"* means an engine that, after the installation of an HDDF retrofit system, can simultaneously operate with diesel fuel and a gaseous fuel, both fuels being metered separately, where the consumed amount of one of the fuels relative to the other one may vary depending on the operation.~~

~~3.7. *"Dual fuel retrofit system type"* means the dual fuel type as defined in par 2. of annex 11 of regulation 49 05 series of amendments or par. 2. of annex 15 of regulation 49 06 series of amendments, as applicable, resulting from the operation of the HDDF retrofit system installed on the parent engine.~~

3.8. "*Retrofit system manufacturer*" means the person or body who is responsible to the approval authority for all aspects of the type-approval of the retrofit system and for ensuring conformity of production.

3.9. "*HDDF retrofitted engine manufacturer*" means the person or body who is responsible to the approval authority for all aspects of the type-approval of the HDDF retrofitted engine and for ensuring conformity of production.

3.10. "HDDF *retrofitted vehicle manufacturer*" means the person or body who is responsible to the approval authority for all aspects of the type-approval of the HDDF retrofitted vehicle and for ensuring conformity of production.

~~3.10. "*Original engine"* means an engine without the installation of the HDDF retrofit system.~~

~~3.11. "*The engine family"* is a set of engines sharing relevant characteristics regarding the installation and the operation of the retrofit system. The family definition is based on the original engine characteristics.~~

~~3.11.1 "*The parent engine*" means an engine that is selected to act as the engine, on which the requirements of this Regulation are going to be demonstrated, and to which the members of a family refer.~~

~~3.11.2. "*A member of the family*" is an engine belonging to the same family of the parent engine.~~

~~3.12. "*Application range*" means the set of engines on which the type approved HDDF retrofit system can be installed.~~

~~3.13. "*Installer*" means an organization which can assume technical responsibility for the correct and safe installation of the approved HDDF LPG and NG retrofit system, in conformity with respectively paragraphs 6.1.1.3. and 6.2.1.3. of this Regulation.~~

~~3.14. "*Engine baseline emission stage*" means the emission limits for the stage to which the original engine was approved.~~

~~3.15. "*Engine system*" means the engine, the emission control system and the communication interface (hardware and messages) between the engine system electronic control unit(s) (ECU) and any other powertrain or vehicle control unit;~~

3.11. *"ESC"* means a test cycle consisting of 13 steady state modes to be applied in accordance with the relevant series of amendments to Regulation No. 49;

3.12. *"ETC"* means a test cycle consisting of 1800 second-by-second transient modes defined in, and to be applied in accordance with the relevant series of amendments to Regulation No. 49;

3.13. "*Scan-tool*" means an external test equipment used for off-board communication with the NCD system.

3.13.1 "*Generic scan-tool*" means a scan-tool, which is publicly available, and which shall be capable to read failure messages.

3.13.2. "*Proprietary scan-tool*" means a scan-tool, which is used only by the REC manufacturer and its authorized dealership, and which shall be capable to read failure messages and to enable an engine start after activation of the operator inducement system.

3.14. *"WHSC"* means a test cycle consisting of 13 steady state modes defined in, and to be applied in accordance with the relevant series of amendments to Regulation No. 49;

3.15. *"WHTC"* means a test cycle consisting of 1800 second-by-second transient modes defined in, and to be applied in accordance with the relevant series of amendments to Regulation No. 49;

3.16. *"Euro IV engine"* means an engine approved regarding exhaust emissions according to row B1 of table 1 and 2 of par. 5.2.1. of regulation 49 03, 04 or 05 series of amendments, or according to row B1 of table 1 and 2 of par. 6.2.1. of Directive 88/77/EEC including the amending Directive 2001/27/CE.

3.17. *"Euro V engine"* means an engine approved regarding exhaust emissions according to row B2 of table 1 and 2 of par. 5.2.1. of regulation 49 03, 04 or 05 series of amendments, or according to row B2 of table 1 and 2 of par. 6.2.1of Directive 88/77/EEC including the amending Directive 2001/27/CE.

3.18. *"EEV engine"* means an engine approved regarding exhaust emissions according to row C of table 1 and 2 of par. 5.2.1. of regulation 49 03, 04 or 05 series of amendments, or according to row C of table 1 and 2 of par. 6.2.1of Directive 88/77/EEC including the amending Directive 2001/27/CE.

3.19. *"Euro VI engine"* means an engine approved regarding exhaust emissions according to regulation 49 06 series of amendments.

4. Application for approval

4.1. Application for approval of a HDDF retrofit system intended to be fitted on road vehicles.

4.1.1. The application for approval of a specific HDDF retrofit system shall be submitted by the retrofit system manufacturer or by his duly accredited representative.

4.1.2. It shall be accompanied by the under-mentioned documents in triplicate and by the following details:

4.1.2.1. Description of the retrofit system comprising all the relevant details, included the approval numbers of each component referred to in ~~Annex~~ ~~3~~ appendix 1 to annex 1.

4.1.2.2. Description of the parent engine on which the requirements of this Regulation are going to be tested;

4.1.2.3. Description of all modifications applied to the original parent engine;

4.1.2.4. Verification of compliance with the specifications prescribed in paragraph 6 of this Regulation;

4.1.2.5. Installation manual(s) for the HDDF retrofit system.

4.1.2.6. End-user manual.

4.1.2.7. A sample of the specific retrofit system, properly installed in the parent engine application(s).

4.2. ~~Dual fuel~~ Application for approval of a HDDF retrofitted engine intended to be fitted on road vehicles

4.2.1. The application for approval of a HDDF retrofitted engine shall be submitted by the retrofitted engine manufacturer or by his duly accredited representative

4.2.2. It shall be accompanied by the under-mentioned documents in triplicate and by the following details:

4.2.2.1. To be defined.

4.3. Application for approval of a HDDF retrofitted ~~road~~ vehicle type with an approved HDDF retrofitted engine

4.3.1. The application for approval of a HDDF retrofitted vehicle with regard to the installation of a HDDF retrofitted engine shall be submitted by the retrofitted vehicle manufacturer or by a duly accredited representative.

4.3.2. It shall be accompanied by the below-mentioned documents in triplicate and the following particulars:

4.3.2.1. To be defined.

5. Markings

5.1. Markings of an approved HDDF retrofit system

5.1.1. The sample(s) of a specific HDDF retrofit system submitted to type approval shall be accompanied by a plate or its drawing with the trade name or mark of the retrofit system manufacturer and the type, as indicated in Appendix 2 to Annex ~~4~~ 1 .

5.1.2. All retrofit systems, installed on the engines belonging to the application range, as defined in paragraph 1.6 of annex 1, shall be identified by an approval mark, in which the approval number and the technical specifications, as required in Annex 4, shall be placed. This approval mark has to be permanently fixed to the engine, shall be durable for the useful life of the device and shall be clearly readable and indelible.

5.1.3. The approval mark shall consist of:

5.1.3.1. A circle surrounding the letter “E” followed by the distinguishing number of the country which has granted the approval;

5.1.3.2. The number of this Regulation, followed by the letter “R”, a dash and the approval number to the right of the circle defined in paragraph 5.1.3.1. The approval number consists of the retrofit system type approval number, which appears in the communication form for this type (see paragraph 6.2. and Annex 5) preceded by two figures indicating the latest series of amendments to this Regulation.

5.2. Markings of an approved HDDF retrofitted engine as a separate technical unit.

5.2.1. To be defined.

5.3. Markings of a retrofitted HDDF vehicle with a HDDF retrofitted engine.

5.3.1. To be defined.

6. Approval

6.1. **Approval of a HDDF retrofit system intended to be fitted on road vehicles.**

6.1.1. Type approval shall be granted if the HDDF retrofit system meets the requirements of this Regulation.

6.1.2. An approval number shall be assigned to each type of the retrofit system approved. Its first two digits (at present 00 according to the Regulation in its original form) shall indicate the series of amendments incorporating the most recent major technical amendments made to the Regulation at the time of issue of the approval. The same Contracting Party shall not assign the same type approval number to another type of retrofit system.

6.1.3. Notice of approval or of refusal or of extension of approval of a retrofit system type/part pursuant to this Regulation shall be communicated to the Parties to the Agreement applying this Regulation, by means of a form conforming to the model in Appendix 3 to Annex ~~5~~1 to this Regulation.

6.1.4. In addition to the Notice specified in par. 6.1.3., when applicable, the application range of the approved HDDF retrofit system shall be communicated to the Parties to the Agreement applying this Regulation by means of a form conforming to the model in Appendix 4 to Annex 1 to this Regulation

6.~~4~~2. **Approval of a HDDF retrofitted engine intended to be fitted on road vehicles**

6.2.1. To be defined

6.3. **Approval of a HDDF retrofitted vehicle type with an approved HDDF retrofitted engine**

6.3.1. To be defined

7. General requirements

7.1. HDDF retrofit system intended to be fitted on road vehicles

7.1.1. The components of NG HDDF retrofit systems shall comply with Regulation no. 110, as applicable.

7.1.2. The components of LPG HDDF retrofit systems shall comply with Regulation no. 67, as applicable.

7.1.3. All requirements of Annex 1 shall be met.

7.2. HDDF retrofitted engine intended to be fitted on road vehicles

7.2.1. The NG components of HDDF retrofitted engine shall comply with Regulation no. 110, as applicable.

7.2.2. The LPG components of HDDF retrofitted engine shall comply with Regulation no. 67, as applicable.

7.2.3. All requirements of Annex 2 shall be met.

7.3. HDDF Retrofitted vehicle with a HDDF retrofitted engine

7.3.1. All requirements of Annex 3 shall be met.

8. Conformity of production

The conformity of production procedures shall comply with those set out in the 1958 Agreement, appendix 2 (E/ECE/324 - E/ECE/TRANS/505/Rev.2).

9. Modification and extension of approvals

9.1. Modification and extension of the approval of a HDDF retrofit system

9.1.1. Every modification relevant in the context of this Regulation of the retrofit system shall be notified to the authority, which granted the type approval. The authority will then assess whether or not the retrofit system still complies with the requirements for inclusion in the appropriate family.

The authority may require a further test report from the technical service responsible for conducting the tests in order to assist in its assessment.

9.1.2 Any modification or extension of the application range, as defined in par. 1.6 of annex 1, is dealt with as a modification or extension of the type approval of the HDDF retrofit system. The provisions of par. 10 of annex.1 shall be met.

9.1.3. Where the type-approval authority approves the modification, a reference to the formal notification of that approval shall be included in the installation manual for the retrofit system.

9.1.4. Confirmation or refusal of approval, specifying the alteration, shall be communicated by the procedure specified in paragraph 6 above to the Parties to the 1958 Agreement applying this Regulation.

9.1.5. The competent authority issuing the extension of approval shall assign a series number for such an extension and inform thereof the other Parties to the 1958 Agreement applying to this Regulation of that number by means of the Communication specified in Annex 5 to this Regulation.

9.2. Modification and extension of the approval of a HDDF retrofitted engine

9.2.1. To be defined.

9.3. Modification and extension of the approval of a HDDF retrofitted vehicle regarding the installation of a HDDF retrofitted engine

9.3.1. To be defined.

10. Penalties for non-conformity of production

10.1. The approvals granted ~~in respect of a type of HDDF retrofit system~~ pursuant to this Regulation may be withdrawn if the requirements laid down in

annexes 1, 2 or 3, as applicable, ~~in paragraph 21 and 22 above~~ are not complied with.

10.2. If a Party to the Agreement applying this Regulation withdraws an approval it has previously granted, it shall forthwith so notify the other Contracting Parties applying this Regulation, by means of the Communication specified in Annex 5 to this Regulation.

11. Production definitely discontinued

11.1. If the holder of the approval completely ceases to manufacture a type of retrofit system, a type of HDDF retrofitted engine or a type of HDDF retrofitted vehicle approved in accordance with this Regulation, he shall so inform the authority which granted the approval. Upon receiving the relevant communication, that authority shall inform thereof the other Parties to the 1958 Agreement applying this Regulation by means of the Communication specified in Annex 5 to this Regulation.

12. Names and addresses of technical services conducting approval tests and of Administrative departments

12.1. The Parties to the Agreement applying this Regulation shall communicate to the United Nations Secretariat the names and addresses of the technical services responsible for conducting approval tests and of the administrative departments which grant approval and to which forms certifying approval or extension or refusal or withdrawal of approval, issued in other countries, are to be sent.

Annex 1 - Requirements for the approval of HDDF retrofit systems intended to be fitted in road vehicles

1. **Definitions**

For the purpose of this annex, the following definitions shall apply in addition to the definitions of par. 3:

1.1. "*Specific Heavy Duty Dual Fuel (HDDF) retrofit system"* means HDDF retrofit systems which do not differ in such respect as:

1.1.1. Retrofit system manufacturer (responsible for retrofit approval application);

1.1.2. Dual fuel retrofit system type

1.1.3. Pressure regulator/vaporizer type by the same manufacturer;

1.1.4. Gas fuelling system type by the same manufacturer (i.e. induction mixer, injector device, vapour or liquid, single or multi-point injection system);

1.1.5. Sensors and actuators set types;

1.1.6. The fuel container type (i.e. LPG liquid take off / vapour pressure, LPG vapour take off, LPG liquid take off / pressurized by pump, pressurized CNG take off), the safety devices and fuel container accessories, as required by Regulation No. 67, 01 series of amendments, or Regulation No. 110, where applicable (i.e. relief valve);

1.1.7. Fuel container fitting devices;

1.1.8. ECU type by the same manufacturer;

1.1.9. Basic software principles and control strategy;

1.1.10. Installation manual;

1.1.11. End-user manual.

1.2. "*Original engine"* means an engine without the installation of the HDDF retrofit system.

1.3. "*The engine family"* is a set of engines sharing relevant characteristics regarding the installation and the operation of the retrofit system. The family definition is based on the original engine characteristics.

1.4. "*The parent engine*" means an engine that is selected to act as the engine, on which the requirements of this Regulation are going to be demonstrated, and to which the members of a family refer.

1.5. "*A member of the family*" is an engine belonging to the same family of the parent engine.

1.6. "*Application range*" means the set of engines on which the type approved HDDF retrofit system can be installed.

1.7. "*Installer*" means an organization which can assume technical responsibility for the correct and safe installation of the approved HDDF retrofit system, in conformity with paragraphs 12 of this annex.

1.8. "*Engine baseline emission stage*" means the emission limits for the stage to which the original engine was approved.

1.9. "*Engine system*" means the engine, the emission control system and the communication interface (hardware and messages) between the engine system electronic control unit(s) (ECU) and any other powertrain or vehicle control unit;

1.10. *"Dual fuel retrofit system type"* means the dual fuel type as defined in par 2. of annex 11 of regulation 49 05 series of amendments or par. 2. of annex 15 of regulation 49 06 series of amendments, as applicable, resulting from the operation of the HDDF retrofit system installed on the parent engine.

2. **Determination of dual fuel retrofit system type**

2.1. *Euro IV, Euro V and EEV parent engines*

In order to determine the dual fuel retrofit type, the Gas Energy Ratio (GER), as defined in par. 2.1 of annex 11 of Regulation 49 05 series of amendments, shall be calculated over the ETC test cycle specified in par. 6.3.1. (b).

2.1.1. The dual fuel retrofit type ~~GER~~ shall be confirmed over the ESC test cycle specified in par. 6.3.1. (a).

~~2.1.2. If GER is relevant to the definition of emission limits in accordance with par. 1.5.3., the absolute difference between the average gas ratio calculated over ETC test cycle (GER_{ETC}) and the average gas ratio calculated over ESC test cycle (GER_{ESC}) shall not exceed 20% of the GER_{ETC}.~~

2.2. *Euro VI parent engines*

In order to determine the dual fuel retrofit type, the Gas Energy Ratio (GER), as defined in par. 2.1 of annex 15 of Regulation 49 06 series of amendments, shall be calculated over the hot part of the WHTC test cycle.

2.2.1. (PEMS to confirm GER ??? - see R 49/06)

2.3. Only dual fuel retrofit system types 1B, 2B and 3B are permitted to be type-approved in accordance with this regulation.

3. **Engine family**

3.1. An engine belongs to the same engine family if shares the following criteria features with the parent engine:

(a) engine manufacturer.

(b) fuel supply type (~~electronic yes/no, pump, common rail...~~mechanical pump or electronic controlled injection)

(c) combustion cycle and cooling medium

(d) engine baseline emission stage

(e) method of air aspiration (turbocharged or normally-aspirated engine)

(f) ~~If the gas fuelling system has a central metering for the whole engine: it has an approved power output between 0.7 and 1.15 times that of the parent engine. If the gas fuelling system as an individual metering per cylinder or groups of cylinders: it has~~ an approved power output per cylinder between 0.7 and 1.15 times that of the parent engine.

(g) water and/or air injection

(h) pollution control system:

(i) exhaust after treatment system

(ii) with or without air injection

(iii) with or without exhaust gas recirculation (EGR)

If the parent engine is not equipped with one or more devices listed above, engines with these devices are allowed.

3.2. The criteria of paragraph 3.1.(a) applies only to engines pursuant to the baseline emission stage in force at the time of the request of HDDF retrofit system type approval.

4. Application range

4.1. The application range is defined by the engine family to which the parent engine belongs.

4.2. The application range may be extended to engines which differ from the parent engine as for one or more of the criteria features set out in subparagraphs from 3.1 a) to f).

A representative engine which differs from the parent engine only for these criteria features shall comply with the requirements set out in par. 10 of this annex.

4.3. If the representative engine meets the requirements of par. 10 of this annex, the application range is extended to the engines sharing with it the criteria features set out in subparagraphs from 3.1 a) to f).

4.4. The application range table as defined in Appendix 4 to this Annex is updated in order to include also the criteria features of the representative engine.

5. Operating modes of dual-fuel engines and vehicles

5.1. *Conditions for a dual-fuel engine to idle using diesel fuel exclusively*

5.1.1. Type 1B dual-fuel engines shall not idle using diesel fuel exclusively in dual-fuel mode.

5.1.2. Types 2B and 3B dual-fuel engines may idle using diesel fuel exclusively.

5.2. *Conditions for a dual-fuel engine to warm-up or start using diesel fuel exclusively in dual fuel mode.*

5.2.1. A Type 1B, Type 2B, or Type3B dual-fuel engine may warm-up or start using diesel fuel solely. However, in that case, it shall operate in diesel mode.

5.2.2. The strategy shall cease to be active when the coolant temperature has reached a temperature of 343 K (70 °C), or within 15 minutes after it has been activated, whichever occurs first.

5.3. *Operability Restriction*

A HDDF retrofit system when operating in a dual-fuel mode shall be designed so as to permit, in case of unavailability of gaseous fuel the switch back to diesel mode. The switch back shall occur as soon as possible in all cases listed in par. 5.3.1. of this annex.

5.3.1. The unavailability of gaseous fuel when operating in dual fuel mode shall provide for the following cases:

- Empty gaseous fuel tank

When the gas availability in the tank exceed the level that justified the activation of the switch back, the dual-fuel mode may be reactivated.

- Malfunctioning gas supply

  The gas injection system electronics, fuel quantity and timing actuator(s) shall be monitored for circuit continuity (i.e. open circuit or short circuit) and total functional failure when the engine operates in dual-fuel mode.

  As soon as the gas diagnostic system concludes that the malfunction is no longer present or when the OBD information is erased by a scan tool, the dual fuel mode may be reactivated.

- Abnormality of gas consumption

  This case is applicable only to DHHF retrofit systems intended to be fitted on Euro VI or later engines.

  In the case of an abnormality of gas consumption in dual-fuel mode the fault codes due to abnormality of gas consumption shall be stored in the gas ECU. The system manufacturer shall provide specific instructions as to read out the fault codes through the OBD bus.

  As soon as the gas diagnostic system concludes that the malfunction is no longer present or when the OBD information is erased by a scan tool, dual fuel mode may be re-activated.

5.4. *Dual-fuel indicators*

5.4.1. Dual-fuel operating mode indicator

Dual-fuel engines and vehicles shall have a visual indicator indicating to the driver the mode under which the engine operates (dual-fuel mode, diesel mode, or, when applicable, service mode).

The characteristics and the location of this indicator are left to the decision of the retrofit system manufacturer and may be part of an already existing visual indication system.

This indicator may be completed by a message display. The system used for displaying the messages referred to in this point may be the same as the ones used for OBD, correct operation of NOx control measures, or other maintenance purposes.

The visual element of the dual-fuel operating mode indicator shall not be the same as the one used for the purposes of OBD (that is, the MI – malfunction indicator), for the purpose of ensuring the correct operation of NOx control measures, or for other engine maintenance purposes.

Safety alerts always have display priority over the operating mode indication.

5.4.1.1. The dual-fuel mode indicator shall be set to diesel emergency mode as soon as a switch back to diesel mode is performed and the indication shall remain as long as the diesel emergency mode is active.

5.4.1.2. The dual-fuel mode indicator shall be set for at least one minute on dual-fuel mode or diesel mode as soon as the engine operating mode is changed from diesel to dual-fuel mode or vice-versa. This indication is also required for at least 1 minute at key-on, or at the request of the retrofit system manufacturer at engine cranking. The indication shall also be given upon the driver's request.

5.4.2. Empty gaseous fuel tank warning system (dual-fuel warning system)

A dual-fuel vehicle shall be equipped with a dual-fuel warning system that alerts the driver that the gaseous fuel tank will soon become empty.

The dual-fuel warning system shall remain active until the tank is refuelled to a level above which the warning system is activated.

The dual-fuel warning system may be temporarily interrupted by other warning signals providing important safety-related messages.

It shall not be possible to turn off the dual-fuel warning system by means of a scan-tool as long as the cause of the warning activation has not been rectified.

5.4.2.1. Characteristics of the dual-fuel warning system

The dual-fuel warning system shall consist of a visual alert system (icon, pictogram, etc…) left to the choice of the manufacturer.

It may include, at the choice of the manufacturer, an audible signal. In that case, the cancelling of that signal by the driver is permitted

The visual element of the dual-fuel warning system shall not be the same as the one used for the OBD system (that is, the MI – malfunction indicator), for the purpose of ensuring the correct operation of NOx control measures, or for other engine maintenance purposes.

In addition the dual-fuel warning system may display short messages, including messages indicating clearly the remaining distance or time before the activation of the operability restriction.

The system used for displaying the messages referred to in this paragraph may be the same as the one used for displaying additional OBD messages, messages related to correct operation of NOx control measures, or messages for other maintenance purposes.

A facility to permit the driver to dim the visual alarms provided by the warning system may be provided on vehicles for use by the rescue services or on vehicles designed and constructed for use by the armed services, civil defence, fire services and forces responsible for maintaining public order.

6. Pollutant emissions requirements

6.1. *Measurement methods*

The emission performance of the parent engine shall be measured using the test procedures associated with the engine baseline emission stage.

6.2. *Parent engine configurations and operational modes*

The parent engine shall be tested in the following configurations and operational modes:

(a) diesel mode without the HDDF retrofit system installed (original parent engine)

(b) diesel mode with the HDDF retrofit system installed

(c) dual fuel mode

6.3 Euro IV, Euro V and EEV parent engines

6.3.1 *Test cycles*

Euro IV, Euro V and EEV parent engines shall submitted to the following test cycles:

(a) ESC

(b) ETC

(c) ELR

6.3.2 *Limit values and relevant pollutants for ESC and ELR cycles.*

The test results as such or corrected according to the par. 6.3.2.1. of this annex, as applicable, shall not exceed the emission limits for all the pollutants listed in table 1 of par. 5.2.1. of 05 series of amendments of Regulation No. 49.

6.3.2.1. The test results in dual fuel mode shall be multiplied by the applicable deterioration factors unless durability test as specified in par. 8. of this annex is carried out.

6.3.2.2. Notwithstanding the requirements of par. 6.3.2., during ESC and/or ELR tests in dual fuel mode using diesel/CNG, at the request of the manufacturer, mass of non-methane hydrocarbons (NMHC) may be measured in place of the mass of hydrocarbons (HC).

In this case the following provisions shall apply:

- the limit of non-methane hydrocarbons NMHC is set equal to hydrocarbons (HC) limit;
- the measured mass of CH4 shall be included in the CO2 emission computation according to par. 9 of this annex.

6.3.3. *Limit values and relevant pollutants for ETC cycle.*

The test results as such or corrected according to par. 6.3.3.1. of this annex, as applicable, shall not exceed the limits for all the pollutants listed in table 2 of par. 5.2.1. of regulation 49 05 series of amendments.

6.3.3.1 The test results in dual fuel mode shall be multiplied by the applicable deterioration factors unless durability test as specified in par. 8. is carried out.

6.3.3.2. Notwithstanding the requirements of par. 6.3.3., during ETC test in dual fuel mode using diesel/CNG, at the request of the manufacturer, the respect of CH4 limit may be derogated. In this case, the measured mass of CH4 shall be included in the CO2 emission computation according to par. 9 of this annex.

6.3.4. *Original parent engine not meeting the engine baseline emission stage*

Notwithstanding the requirements of paragraphs 6.3.2. and 6.3.3. of this annex, if the test results relating to the configuration (a) of par. 6.2. of this annex exceed the applicable limits for one or more pollutants, the test results for such pollutants relating to the configurations (b) and/or (c) of par. 6.2. of this annex may be corrected according to the following formula:

$Res_x = Res_{xmeas} - (Res_{x(a)} - Lim_x)$

where:

Res_x is the corrected test result of pollutant x to be applied in par. 6.3.2. and/or 6.3.3. of this annex as for the configurations (b) or (c) of par. 6.2. of this annex;

Res_{xmeas} is the test result of pollutant x in the configurations of par. 6.2. of this annex, subparagraphs (b) and (c);

$Res_{x(a)}$ is the test result of pollutant x in the configuration of par. 6.2. of this annex, subparagraph (a);

Lim_x is the applicable limit of pollutant x in the configuration of par. 6.2. of this annex, subparagraph (a).

This provision is applicable only at request of the retrofit system manufacturer if both the following conditions are met:

a) it can be demonstrated that no other equivalent engine can be submitted as parent engine for type approval of the HDDF retrofit system.

b) no confirmed and active DTC in original OBD system.

6.4 Euro VI parent engines

6.4.1 *Test cycles*

Euro VI and later parent engines shall be submitted to the following test cycles:

(a) WHSC

(b) WHTC

6.4.2 *Limit values and relevant pollutant for WHSC and WHTC cycles.*

The test results as such or corrected according to par. 6.4.3. of this annex shall be below the limits listed in the following paragraphs of annex 15 of regulation 49 06 series of amendments, according to the dual fuel retrofit system type:

- par. 5.1 for type 1B dual fuel retrofit systems;
- par. 5.2 for type 2B dual fuel retrofit systems;
- par. 5.3 for type 3B dual fuel retrofit systems.

6.4.3. The test results in dual fuel mode shall be multiplied by the applicable deterioration factors unless durability test as specified in par. 8. of this annex is carried out.

6.5. Power requirements

6.5.1 *Parent engine configuration and operational modes*

The parent engine in the configuration of par. 6.2. subparagraph (b) and (c) of this annex, shall be submitted to the test procedures of paragraph 6.5.2. of this annex.

The measured power in configuration (c) shall be lower than that measured in configuration (b) multiplied by 1,05.

6.5.2. *Measurement method*

The maximum power at the crankshaft is measured on an engine dynamometer according to Regulation No. 85 (engine dynamometer method).

6.5.3. *Power ratio*

For each engine of the family, the official value of the engine power in dual fuel mode shall calculated multiplying the official value in diesel mode by the following ratio:

$K_{power} = Power_{dualfuel} / Power_{diesel}$

Where:

$Power_{dualfuel}$: measured engine power of the parent engine in configuration (c) of par. 6.2. of this annex.

$Power_{diesel}$: measured engine power of the parent engine in configuration (b) of par. 6.2. of this annex.

7. Requirements and tests for HDDF retrofit system OBD

7.1. The HDDF retrofit system shall implement an OBD system which comply with the following requirements:

(a) During diesel operations the diesel OBD system shall remain the only on board diagnostic system of the vehicle. The MI shall activate in case of detected malfunction;

(b) During dual fuel operations the diesel OBD system shall continue to monitor the original emission related components in use. The MI shall activate in case of a detected malfunction;

(c) During dual fuel operations the dual fuel ECU shall only monitor the dual fuel emission-related components as well as their electrical connections. If the dual fuel ECU detects a malfunction, the switch to diesel mode shall be performed as soon as possible. Operation in dual fuel mode shall not be possible until the cause of the malfunction is removed and a clear visual or acoustic signal shall inform the driver about this situation.

7.2. The DHHF retrofit system OBD shall be submitted to the following tests, carried out on the parent engine:

(a) In diesel mode the original malfunction indicator (MI) shall activate due to the electrical disconnection of any original emission-related component;

(b) In dual fuel mode the original MI shall activate due to the electrical disconnection of any original emission-related component, which is in use during dual fuel operations.

(c) In dual fuel mode the automatic switch to diesel mode shall occur due to replacement of any dual fuel emission-related component with a deteriorated and defective one or electronic simulation of such a failure.

7.3. Fault codes referring to malfunctions of the gas emission-related components and their electrical connections shall be stored in the dual fuel ECU. The fault codes shall be available through the OBD bus or through a dedicated communication line.

7.4. The system manufacturer shall provide specific instructions as to read out the LPG fault codes referred to in paragraph 7.3. of this annex in case of a dedicated communication line.

8. Durability requirements

8.1. The applicant shall declare that the HDDF retrofit system when used and maintained according to the manufacturer's instructions will comply with the applicable provisions during normal operation over a useful life of:

a) for category M2 and M3 and N vehicles, a mileage of 200 000 km or a service life of 6 years, whichever occurs first,

b) for all other applications, 4 000 operating hours or a service life of 6 years, whichever occurs first.

8.2. The applicant shall conduct a 1000 hours durability test on the parent engine equipped with the HDDF retrofit system. This test shall be either a field test in a typical vehicle or machine application agreed between the Type Approval Authority and the applicant or a test on an engine test bed using an appropriate duty cycle. In the case of testing on an engine test bed, the aging cycle, load and speed shall include conditions that approximate to 10% idle, 10% transient operation, 75% high speed-high load operation, and 5% low speed-medium load operation.

8.3. The content of the test is as follows:

- 1000 hours of operation of the HDDF with recording of all relevant operating data of the engine concerned including type and consumption of fuel and continuous second-by-second data logging of exhaust temperature, type and consumption of fuel. In the case of a field test the HDDF retrofit system must be sealed by the Technical Service and the data-logging shall be carried out by the system manufacturer or by the operator of the vehicle or machine on which the endurance test is performed.

8.4. The parent engine and the HDDF retrofit system submitted to the durability test shall be used to demonstrate the exhaust emission requirements as specified in par. 6. of this annex.

9. CO_2 emissions

9.1. For each member of the family, the official value of CO_2 emissions in dual fuel mode shall be calculated multiplying the official value in diesel mode by the following factor:

$K_{CO2} = (CO2_{DF} + CO2_{CH4DF})/ CO2_{DIESEL}$

where:

$CO2_{DF}$ is the measured value of the CO_2 emissions of the parent engine tested in configuration (c) of par. 6.2 of this annex over the ESC test

$CO2_{CH4DF}$ is the CO2 equivalent emission of CH_4 emissions of the parent engine tested in configuration (c) of par. 6.2 of this annex over the ESC test.

$CO2_{DIESEL}$ is the measured value of the CO_2 emissions of the parent engine tested in configuration (b) of par. 6.2 of this annex over the ESC test.

$CO2_{CH4DF}$ shall be included only if, by virtue of par. 6.3.2.2, CH4 emissions are counted as CO_2 equivalent emissions.

It results from the following formula:

$CO2_{CH4DF} = CH4_{DF} \times 23$

where:

$CH4_{DF}$ is the measured value of CH_4 emissions of the parent engine tested in configuration (c) of par. 6.2 of this annex over the ESC test.

10. Extension of the application range

10.1 Tests and requirements

A representative engine as defined in par. 4.2 shall be tested in accordance with the provisions set out in par 10.1.1 or, alternatively, in par 10.1.2, at the choice of the HDDF retrofit system manufacturer.

10.1.1 Engine testing

10.1.1.1 Emission tests

10.1.1.1.1 Euro IV, V and EEV engines

An ESC bench test shall be carried out on a representative engine equipped with a HDDF retrofit system-type.

The test procedures and results shall comply with the applicable provisions of par. 6.3.

10.1.1.1.2 Euro VI engines

An WHSC bench test shall be carried out on a representative engine equipped with a HDDF retrofit system-type.

The test procedures and results shall comply with the applicable provisions of par. 6.3.

10.1.1.2 OBD requirements and tests

The representative engine equipped with the HDDF retrofit system shall comply with provisions set out in paragraph 7 of this Annex.

10.1.1.3 Power measurement

The representative engine equipped with the HDDF retrofit system shall comply with provisions set out in paragraph 6.5 of this Annex.

10.1.1.4 CO2 emissions measurement

10.1.1.4.1 Euro IV, V and EEV engines

CO2 emission shall be measured on a ESC bench test carried out on a representative engine equipped with a HDDF retrofit system-type.

10.1.1.4.2 Euro VI engines

CO2 emission shall be measured on a WHSC bench test carried out on a representative engine equipped with a HDDF retrofit system-type.

10.1.2 Vehicle testing

TO BE DEFINED

10.2 Power ratio

For each engine sharing with the representative engine the criteria features set out in subparagraphs from 3.1 a) to f), the official value of the engine power in dual fuel mode shall calculated multiplying the official value in diesel mode by the following ratio:

K_{power} = $Power_{dualfuel}$ / $Power_{diesel}$

Where:

$Power_{dualfuel}$: measured engine power of the representative engine in dual fuel mode tested in accordance with paragraph 10.1.1.3 or, alternatively, with par. XXX.

$Power_{diesel}$: measured engine power of the representative engine in diesel mode tested in accordance with paragraph 10.1.1.3 or, alternatively, with par. XXX..

10.3 CO2 ratio

For each engine sharing with the representative engine the criteria features set out in subparagraphs from 3.1 a) to f), the official value of CO_2 emissions in dual fuel mode shall be calculated multiplying the official value in diesel mode by the following factor:

K_{CO2} = ($CO2_{DF}$ + $CO2_{CH4DF}$)/ $CO2_{DIESEL}$

where:

$CO2_{DF}$ is the measured value of the CO_2 emissions of the representative engine in duel fuel mode tested in accordance with par. 10.1.1.4 or, alternatively, with par XXX

$CO2_{CH4DF}$ is the CO2 equivalent emission of CH_4 emissions of the representative engine in dual fuel mode tested in accordance with par. 10.1.1.4 or, alternatively, with par XXX

. $CO2_{DIESEL}$ is the measured value of the CO_2 emissions of the representative engine in diesel mode tested in accordance with par. 10.1.1.4 or, alternatively, with par XXX

$CO2_{CH4DF}$ shall be included only if, by virtue of par. 6.3.2.2, CH4 emissions are counted as CO_2 equivalent emissions.

It results from the following formula:

$CO2_{CH4DF}$ = $CH4_{DF}$ x 23

where:

$CH4_{DF}$ is the measured value of CH_4 emissions of the representative engine in dual fuel mode tested in accordance with par. 10.1.1.4 or, alternatively, with par XXX

12. Installation manual.

12.1. Scope

The scope of this paragraph is to list the minimum requirements which shall be contained in the installation manual.

12.2. General requirements

12.2.1. The installation manual has the purpose to guide the installer through the correct procedures which shall be observed while assembling the HDDF retrofit systems.

12.2.2. The installation manual shall be prepared by the HDDF retrofit system manufacturer.

12.2.3. The installation manual is part of the retrofit system and therefore shall be available to the installer for each conversion kit.

12.2.4. The installation manual shall be written in the language of the country to which the conversion retrofit will be delivered, or at least in English.

12.2.5. The installation manual can be divided in two parts:

Part I:

(a) Part containing the description of the sample of the HDDF retrofit system;

(b) Part containing the list of components indicated by the retrofit system manufacturer as alternatives.

Part II:

(a) Part containing installation instructions for the specific vehicle.

12.2.6. Installation manual of the parent vehicle has to be submitted to the authority that grants the type approval.

12.2.7. Installation manual of the vehicles belonging to the family has to be filed by the retrofit system manufacturer for a time to be determined in accordance with the authority that grants the type approval.

12.3. Contents of Part I, section (a) of installation manual

12.3.1. HDDF retrofit system description

12.3.1.1. Operational principles of the HDDF retrofit system

12.3.1.2. Operational principles of each component of the HDDF retrofit system

12.3.2. Proper assembly check

12.3.2.1. The installation manual shall contain the detailed procedures and actions which shall be taken by the installer to check whether the system has been assembled in order to safely perform and to abide by the installation instructions.

12.3.3. Start-up procedures

12.3.3.1. The installation manual shall contain the start-up operations which shall be performed by the installer.

12.3.4. Service instructions

12.3.4.1. The installation manual shall contain the maintenance schedule in which all the ordinary service (type) which the single components as well as the system shall undergo through their working life (time in km covered by the vehicle) will be specified.

12.3.4.2. The installation manual shall specify the expertise necessary for the installation/service of the system.

12.3.5. System malfunction

12.3.5.1. The installation manual shall contain the actions which shall be taken in case the system malfunctions.

12.3.6. Diagnosis

12.3.6.1. If a diagnosis system is included in the conversion kit, the installation manual shall contain a detailed description of such a system together with the corrective actions which may be taken in case of malfunctioning.

12.4. Contents of Part II of installation manual

12.4.1. HDDF retrofit system identification

12.4.1.1. HDDF retrofit system approval number

12.4.1.2. Vehicle manufacturer

12.4.1.3. Vehicle category

12.4.1.4. Vehicle type

12.4.1.5. Engine type

12.4.1.6. Engine displacement

12.4.1.7. Transmission type

12.4.1.8. Vehicle model

12.4.1.9. Type of fuel

12.4.1.10. Assembly instruction number

12.4.1.11. General scheme of the HDDF retrofit system containing the following information of each component:

(a) Identification number;

(b) Manufacturer's code;

(c) Type approval, if it exists;

(d) For the containers: capacity/manufacturer/type/date of expiry or replacement date, if it exists.

12.4.1.12. Description (including drawings, if applicable) of the fitting devices of the container installation on the vehicle.

12.4.2. Installation instructions

12.4.2.1. Assembly instructions of all components together with diagrams or photographs showing clearly the layout of the single components within the engine compartment.

12.4.2.2. Diagram or photograph showing the exact position where the installer shall place the retrofit system type approval plate (contained in the conversion kit).

12.4.2.3. Clear wiring diagram of the electrical system containing the mechanical components to which the wires shall be connected.

12.4.3. Scrapping of the product

The manual shall give proper indication to the installer about precautions to be taken when the system has to be removed from the vehicle.

13. End-User manual

13.1. Scope

To specify the minimum requirements of the end-user manual for HDDF retrofit systems maintenance.

13.2. General requirements

13.2.1. The user manual has the purpose to inform the end-user about the characteristics and safety features of the installed HDDF retrofit systems.

13.2.2. The user manual shall be prepared by the HDDF retrofit system manufacturer.

13.2.3. The manufacturer of the system shall include all the necessary information that is needed for correct use and safe operation of the HDDF retrofit systems.

13.2.4. The user manual shall be considered as an integral part of the system and therefore be delivered with the HDDF retrofit systems.

13.2.5. The user manual shall be written in the language of the country to which the system is delivered.

13.2.6. The user manual shall indicate reference to the product type and version and production year for which it is applicable.

13.2.7. Information shall be given for relevant extreme ambient conditions.

13.3. Contents of the end-user manual

13.3.1. Technical specifications

The user manual shall contain at least the following information:

(a) Operating characteristics

(b) Performance under normal operating conditions

(c) Extreme ambient conditions.

13.3.2. Safety instructions

The user manual shall give warning for dangers to health and safety categorised in the following way:

(a) SUGGESTIONS for optimal use of the system

(b) ATTENTION for possible problems due to misuse

(c) WARNING for damage to persons or goods when procedures are not followed.

If and when safety symbols are used, they shall be in accordance with the international system, SI and their purpose shall be clearly specified in the user manual.

The user manual shall indicate proper actions to be taken in case the vehicle is repainted and put in a hot drying cabin.

13.3.3. HDDF retrofit systems description

All the components of the HDDF retrofit systems shall be clearly described for their purpose, use and function.

13.3.4. First use and adjustment of the HDDF retrofit systems

The user manual shall contain all the necessary information to the end user about initial running in and or adjustment of the system when needed.

13.3.5. Operating of the HDDF retrofit systems

13.3.5.1. Filling of the HDDF retrofit systems

The user manual shall indicate the sequence of operations needed to fill up the gas containers. Particular attention shall be paid to the maximum filling level of the 80 per cent in case of LPG.

13.3.5.2. Switch-over procedure

The user manual shall clearly describe the method of switching over from one mode to the other by giving the sequence of operations.

13.3.5.3. Opening/closing of manual valves

When fitted, the user manual shall indicate the proper procedure to operate the manual valves.

13.3.5.4. Level indicator

The user manual shall state the location of the level indicator, for example at the dashboard or at the container. Its read-out has to be clearly explained to the user, giving particular attention to the 80 per cent filling level in case of LPG.

13.3.5.5. Maintenance

If maintenance is required, the user manual shall state the frequency and type of maintenance to be carried out.

13.3.5.6. Defects and repair

The user manual shall indicate which actions have to be taken in the case of a defect of the system. When the system is equipped with a diagnosis system the user manual shall describe this system and indicate proper actions to be taken.

13.3.5.7. Scrapping of the product

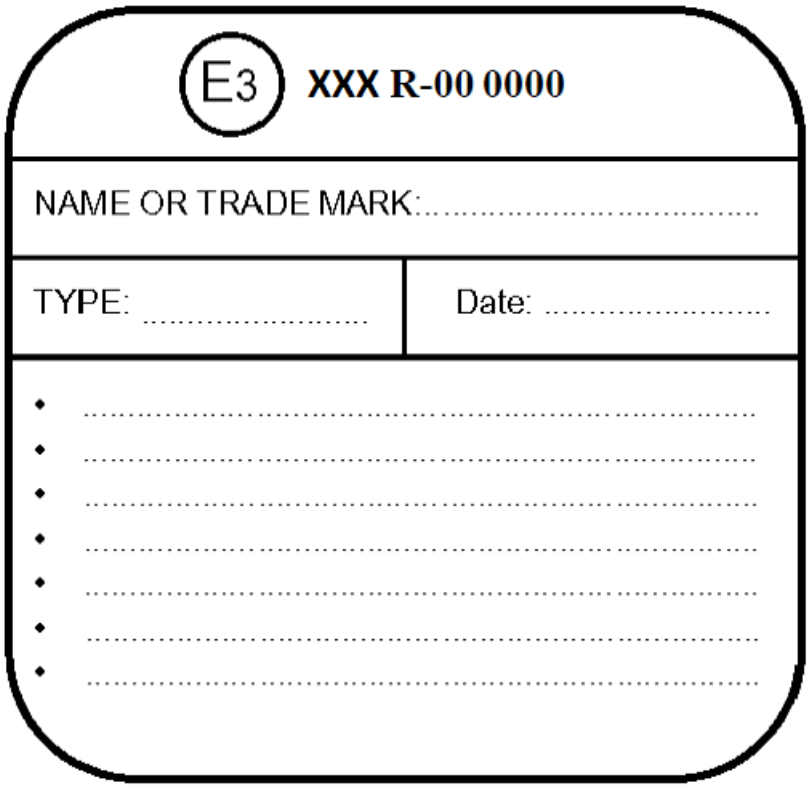
The user manual shall give proper indication that the HDDF retrofit system shall be removed from the vehicle by an installer.

Annex ~~3~~ 1 Appendix 1 - Information document on HDDF retrofit system intended to be fitted in road vehicles

Annex 4-1 Appendix 2 - Arrangement of the HDDF retrofit system type approval mark

XXX R 00 0000

The above approval mark affixed to the plate of HDDF retrofit system, shows that it has been approved in Italy (E3), pursuant to Regulation No. XXX under approval number 000000. The first two digits of the approval number indicate that approval was granted in accordance to the requirement of Regulation No. XXX in its original form.



The above plate, with approval mark and some technical information on the HDDF retrofit system, has to be permanently fixed on the body of the vehicle.

Annex ~~5~~ 1 Appendix 3 - Communication

Annex 1 Appendix 4 - Addendum to the Communication. Application range of the HDDF retrofit system.

(Approval No. ..... Extension No. .....)

1.0. Application range of the approved HDDF retrofit system:

All the vehicles equipped with engines fulfilling the criteria features below are qualified for the approved HDDF retrofit system

	Criteria features 1 (parent engine)	Criteria features 2 (Extension 1)	....
Engine manufacturer[1]			
Fuel supply type			
Combustion cycle and cooling medium			
Engine baseline emission stage			
Method of air aspiration			
Approved output power range [kW/cylinder]			
Water/air[2] injection			
Pollution control sistems: • exhaust after treatment system • Air injection yes/no[2] • EGR yes/no[2]			
K_{CO2}			
K_{powe}			

[1] if applicable
[2] Strike out what doesn't apply

Annex 2 - Requirements for the approval as a separate technical unit of HDDF retrofitted engines intended to be fitted in road vehicles

Annex 3 - Requirements for the installation of a HDDF retrofitted engines on HDDF retrofitted vehicles.